DRAFT

10046

Regolith Breccia

663 grams

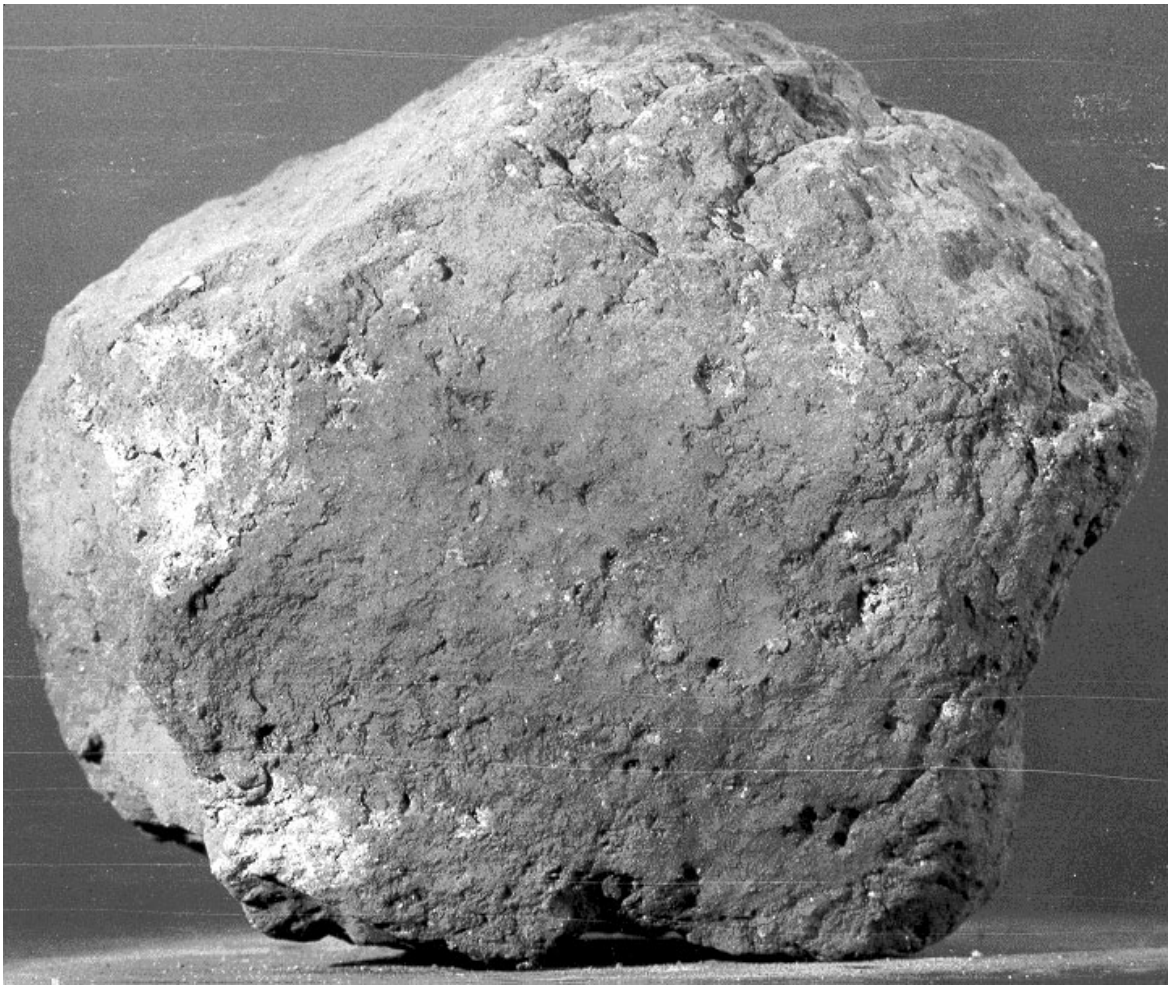


Figure 1: Photo of 10046 before processing. NASA S69-45628. Sample is 10 cm across.

Introduction

Kramer et al. (1977) and Fruland (1983) describe 10046 as a friable, dark grey regolith breccia (figure 1). Phinney et al. (1976) reported that 10046 "*contains a large number of agglutinates*".

10046 was photographed before collection on the lunar surface (see Schmitt et al. 1970 and Sutton and Schaber 1971) and the lunar orientation is known. Bloch et al. (1971) reported on two large micrometeorite craters.

Petrography

Lovering and Ware (1970) described 10046 as a breccia composed of lunar volcanic rack fragments, fragments of minerals from the rocks, spherules and irregular fragments of glass set in a very fine-grained matrix which seems to be glass or devitrified glass. Fruland (1977) found that "the matrix components display a seriate grain size distribution." Schmitt et al. (1970) reported the bulk density as 2.45 g/cm^3, while Anderson et al. (1970) and Chung et al. (1971) determined 2.21 g/cm^3. Porosity was determined as 25 % (Phinney et al. 1976).

Agrell et al. (1970), Lovering and Ware (1970) and Chao et al. (1970) note that glassy spheres, occasionally broken, are conspicuous in all the Apollo 11

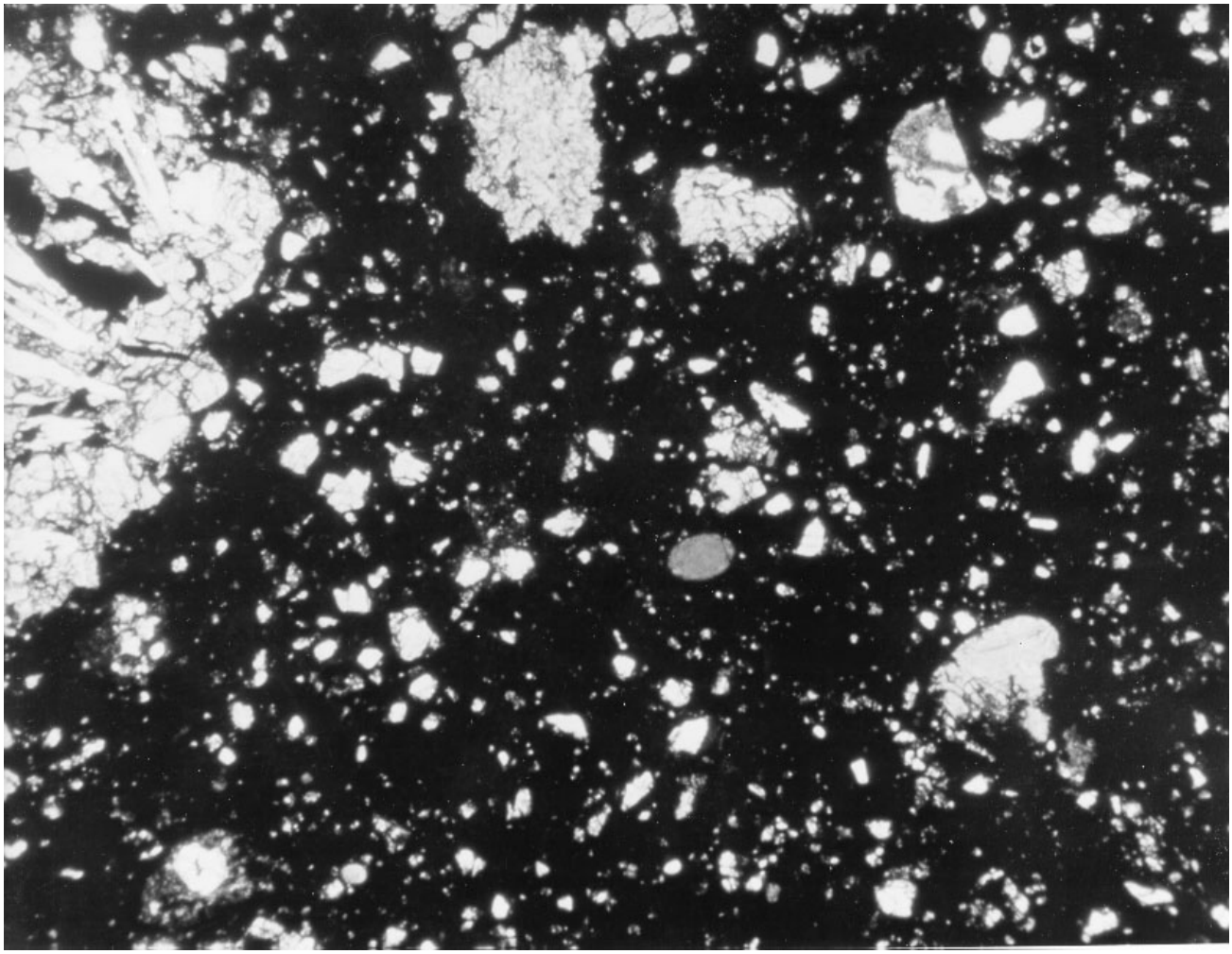


Figure 2: Thin section photomicrograph of 10046,65 showing matrix with orange glass bead and rock fragments as clasts. NASA S70-19511. Scale is 2.5 mm.

microbreccias. In thin section 10046,48 they also noted thin veins of yellow glass and a variety of other glass. However, Essene et al. (1970) were the first to understand the importance of the red-brown glass spheres (figure 2, table 2).

King et al. (1970) studied a small basalt fragment in 10046 (figure 3).

Mineralogy

K-spar: Agrell et al. (1970) reported an intergrowth of "ternary feldspar" with ~$Or_{77}Ab_{21}An_2$ with silica "probably tridymite".

Glass spheres: Essene et al. (1970), Lovering and Ware (1970), von Engelhardt et al. (1970) and others reported the composition of red-brown glass spheres in 10046 (table 2). It turns out that these glass spheres have a life of their own – see section on 74220.

Glass: Keil et al. (1970), Chao et al. (1970) and Dence et al. (1970) give the compositions of some "re-crystallized" glass particles in 10046.

Chemistry

The rare earth element content of this regolith breccia is substantially higher than for the soil 10084 – see figure 4.

Morrison et al. (1970) reported relatively high values of N, F, Cl and Zn (table 1). Using the Kjeldahl method, Muller (1972) also found high (131 ppm) values for chemically bound nitrogen in a chip of 10046. Lovering and Hughes (1971) reported the concentration of Re and Os.

Eberhardt et al. (1972) determined the trapped solar wind gases in 10046. Funkhouser et al. (1971) studied the types of gas that were released on simple

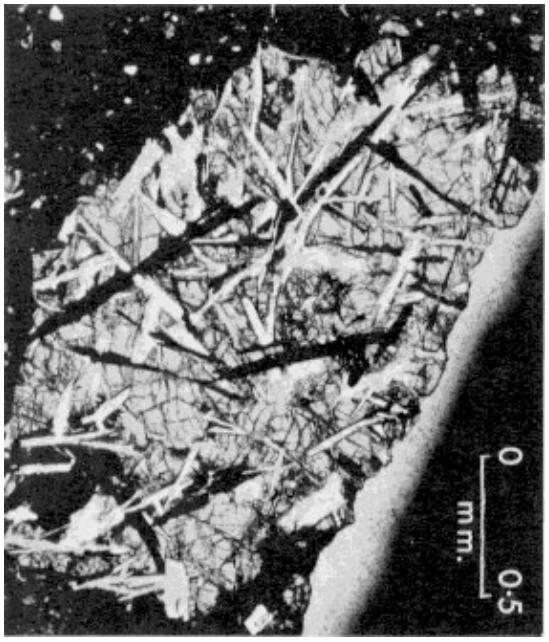


Figure 3: Thin section photo of basalt clast in 10046 (from King et al. 1970).

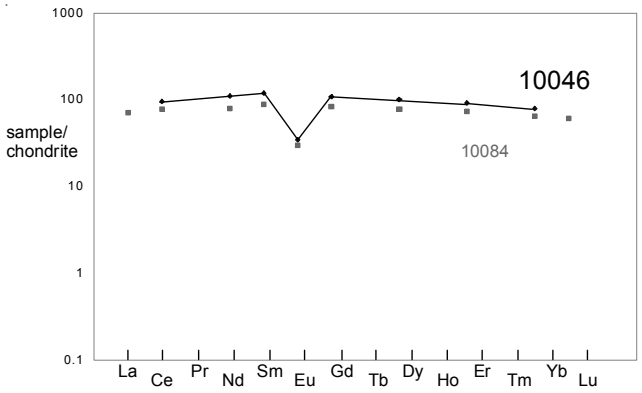


Figure 4: Normalized rare earth element diagram for breccia 10046 compared with soil 10084 (data from Philpotts et al. 1970).

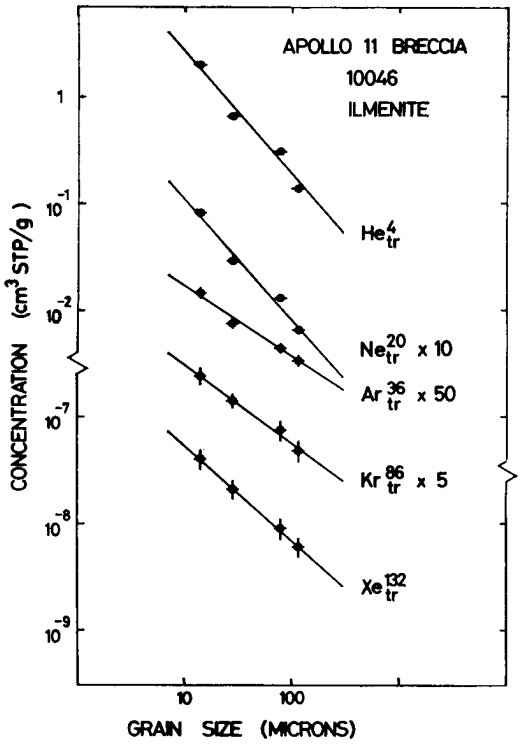


Figure 5: Fine grain ilmenite separates from breccia 10046 contain more rare gas than coarser fraction (from Eberhardt et al. 1972).

crushing of 10046 (H_2, N_2, CH_4, He and Ar) and the isotopic ratios of He and Ar. Eberhardt et al. (1972) studied the temperature release for different grain size of ilmenite, showing that ilmenite had superior trapping power (figure 5). Hintenberger et al. (1971, 1975) also determined the rare gas abundance and isotopic ratios.

Eugster and Bernas (1971) studied the isotopic composition of Li, B, Mg and Ti.

Friedman et al. (1970) determined the gas content evolved from heating 10046 is vacuum and in O_2. They found 100 ppm hydrogen with low D/H ratio and 200 ppm C. The total organic carbon content of 10046 was also determined by hydrogen flame ionization pyrolysis (Ponnamperuma et al. 1970).

Anderson et al. (1970) and Chung et al. (1971, 1972) determined the compressibility, seismic velocity and other physical properties of 10046.

Processing

Apollo 11 samples were originally described and cataloged in 1969 and "re-cataloged" by Kramer et al. (1977). According to Kramer et al. this breccia is said to have first been studied in the "Bio Prep Lab" and as such may have been originally "contaminated" in the Bio-Prep Lab. It was later sawn and chipped in the SSPL.

List of Photo #s for 10046

S69-45621 mug shot
S69-45657
S69-59843 TS
S75-33425
See photo of thin section in Lovering and Ware (1970).

Table 1. Chemical composition of 10046.

reference	Philpotts70		Kharkar71		Morrison 70		Wasson70		Lovering71	
weight	311 mg									
SiO2 %					44.1	(c)				
TiO2			9	(b)	8.34	(c)				
Al2O3					11.7	(c)				
FeO			15.6	(b)	17	(c)				
MnO			0.21	(b)	0.21	(c)				
MgO					9.1	(c)				
CaO			12.3	(b)	13.7	(c)				
Na2O			0.5	(b)	0.47	(c)				
K2O	0.195	(a)			0.2	(c)				
P2O5					0.23	(c)				
S %										
sum										
Sc ppm			72	(b)	64	(c)				
V					68	(c)				
Cr			2150	(b)	2100	(c)				
Co			27	(b)	42	(c)				
Ni										
Cu					9.7	(c)				
Zn					30	(c)				
Ga					4.9	(c)				
Ge ppb							390	(d)		
As					50	(c)				
Se					400	(c)				
Rb	4.22	(a)			3.6	(c)				
Sr	165	(a)			170	(c)				
Y					190	(c)				
Zr					620	(c)				
Nb					38	(c)				
Mo					0.7	(c)				
Ru										
Rh										
Pd ppb					100	(c)				
Ag ppb					20	(c)				
Cd ppb					800	(c)				
In ppb					80	(c)	16	(d)		
Sn ppb										
Sb ppb					5	(c)				
Te ppb										
Cs ppm					0.2	(c)				
Ba	219	(a)			280	(c)				
La			18.6	(b)	23	(c)				
Ce	58	(a)	52.3	(b)	67	(c)				
Pr					20	(c)				
Nd	50.2	(a)			60	(c)				
Sm	17.7	(a)	9.7	(b)	20	(c)				
Eu	1.94	(a)	2	(b)	2	(c)				
Gd	21.5	(a)			20	(c)				
Tb					4.5	(c)				
Dy	24.9	(a)	19.9	(b)	30	(c)				
Ho					9	(c)				
Er	14.8	(a)			23	(c)				
Tm					1.6	(c)				
Yb	13	(a)	10.2	(b)	20	(c)				
Lu			1.93	(b)	1.8	(c)				
Hf			13.4	(b)	11	(c)				
Ta			1.4	(b)	1.7	(c)				
W ppb					0.35	(c)				
Re ppb									0.67	(d)
Os ppb									7.6	(d)
Ir ppb							11.6	(d)		
Pt ppb										
Au ppb							2.8	(d)		
Th ppm					2.8	(c)				
U ppm					0.58	(c)				

technique: (a) IDMS, (b) INAA, (c) various, (d) RNAA

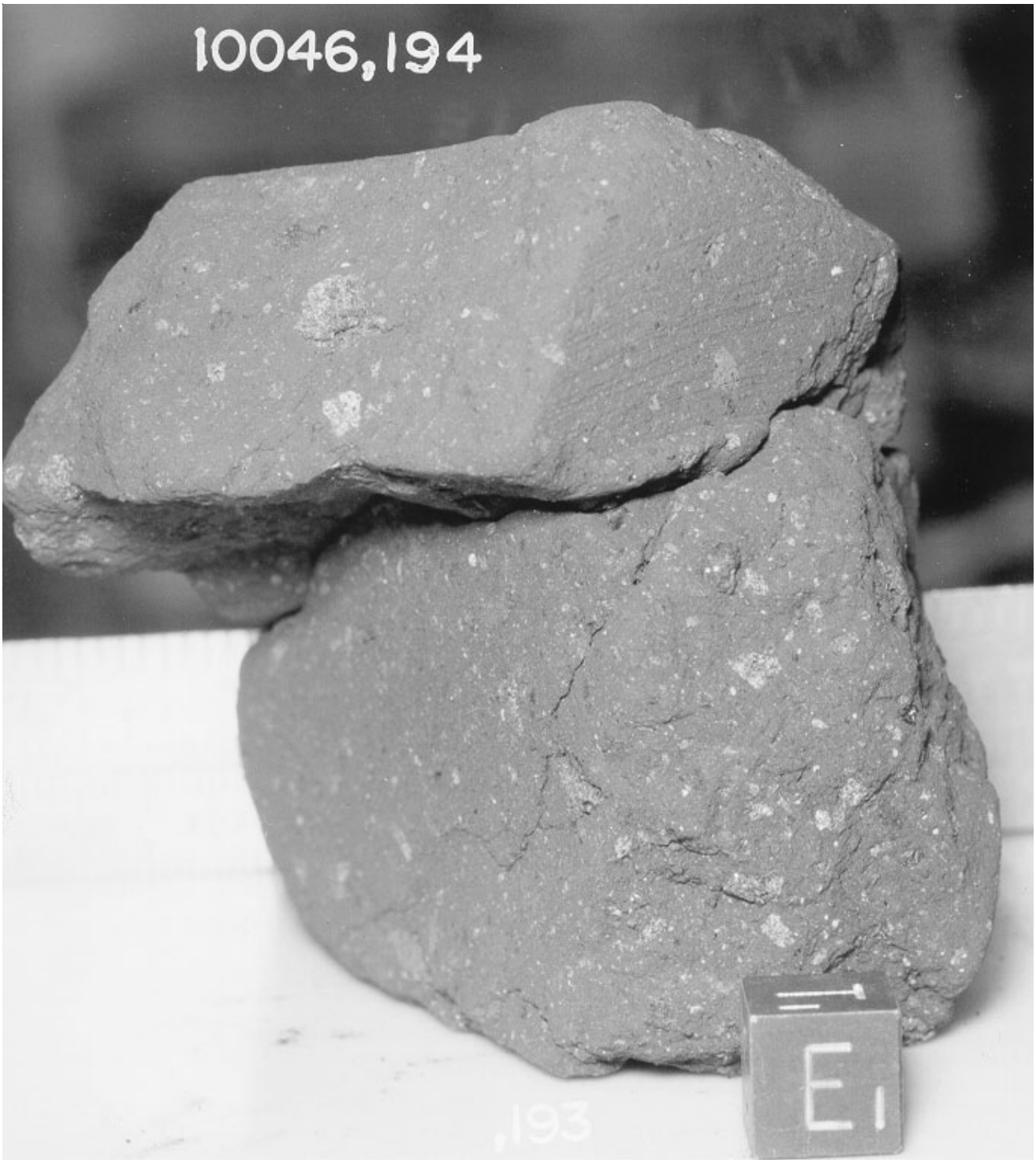


Figure 6: Photo of 10046,194 and ,193 showing internal texture. Cube is 1 cm. NASA S75-33424.

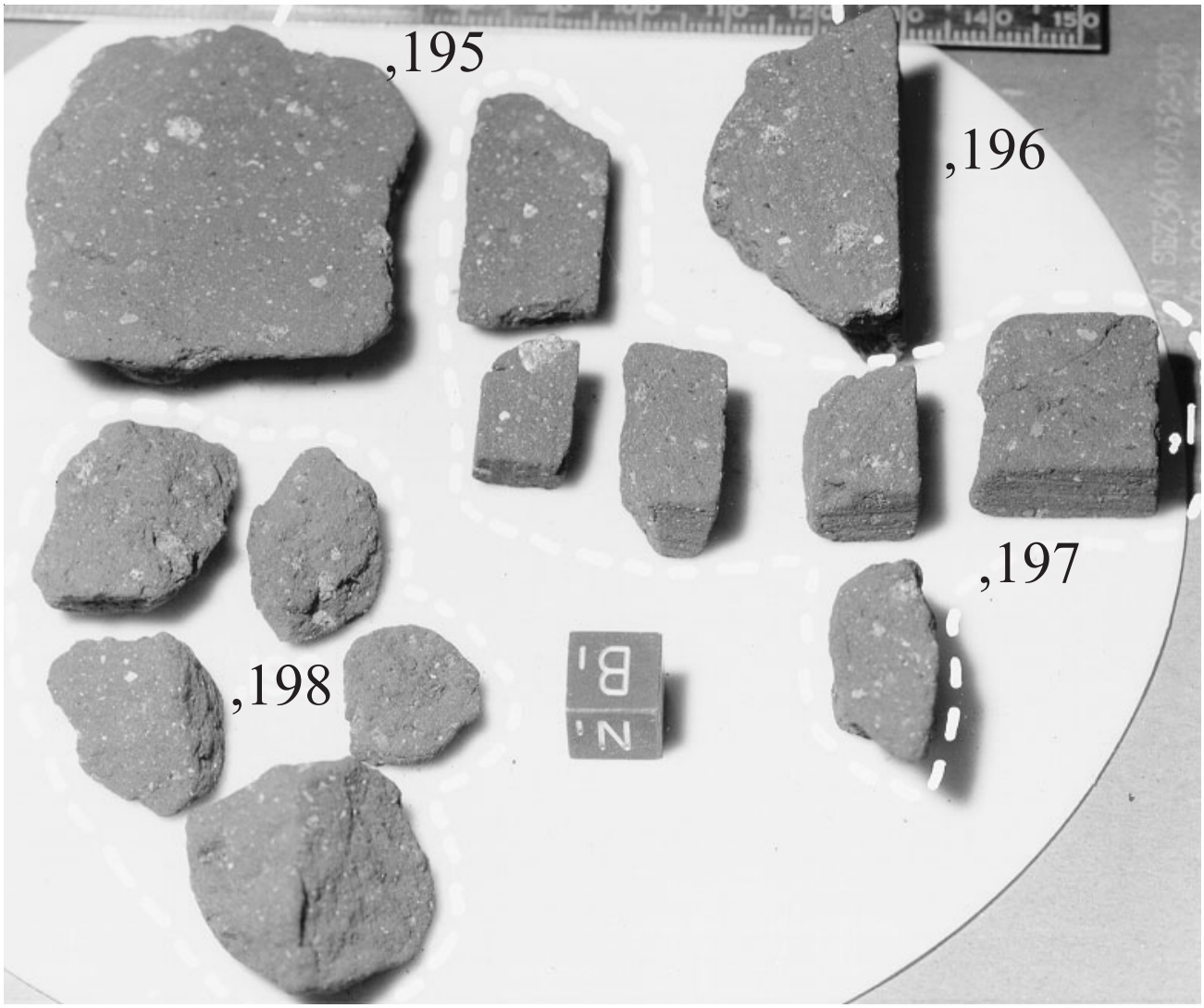
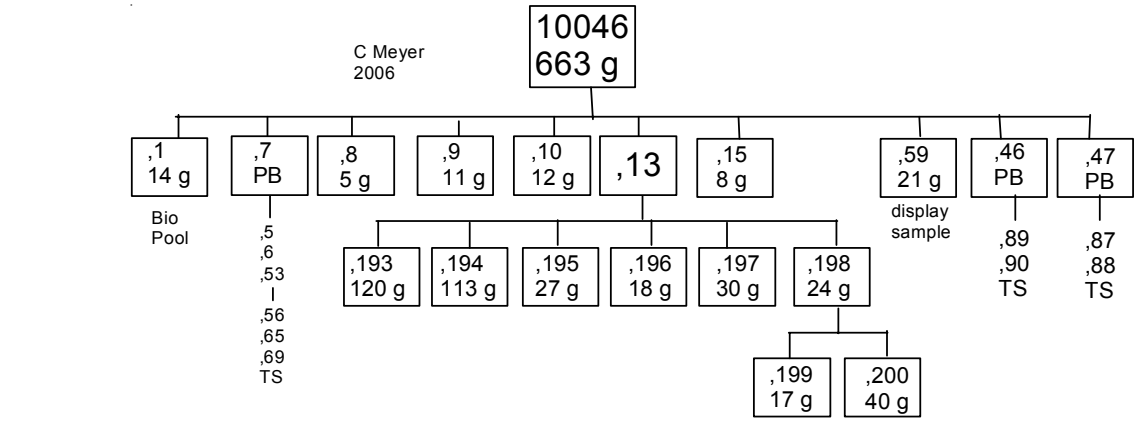


Figure 7 : Group photo of pieces of 10046. NASA S75-33599. Cube is 1 cm.

Table 2. Composition of red-brown glass spheres (A11).

	Essene 70	Lovering70	Engelhardt70		Delano81	Shearer93	Chao70	Keil 70	Reid 70
	10046	10046	10065						10018
#	19	7	1	1	75	3	10	22	1
SiO2	33.81	39.17	34.56	34.88	37.3	38.14	39	37.2	37.6
TiO2	10.05	10.01	9.73	9.83	10	9.83	9.8	10.7	10.04
Al2O3	5.24	5.11	5.36	5.28	5.68	4.46	5.1	5.2	6.49
FeO	23.41	23.42	24.21	23.99	23.7	24.28	23.2	24.7	24.3
MnO	0.33	0.35	0.22	0.18		0.26		0.3	
MgO	13.84	14.17	12.96	13.12	14.3	14.7	13.4	13.1	14.3
CaO	7.41	7.22	7.03	7.06	7.62	7.22	7.5	7.7	7.65
Na2O	0.28	0.27	0.37	0.4	0.31	0.21	0.2	0.27	0.36
K2O	0.07	0.05	0.05	0.05		0.05	0.12	0.04	0.14
Cr2O3	0.53	0.56			0.63	0.68	0.57	0.61	0.54
						+ trace			



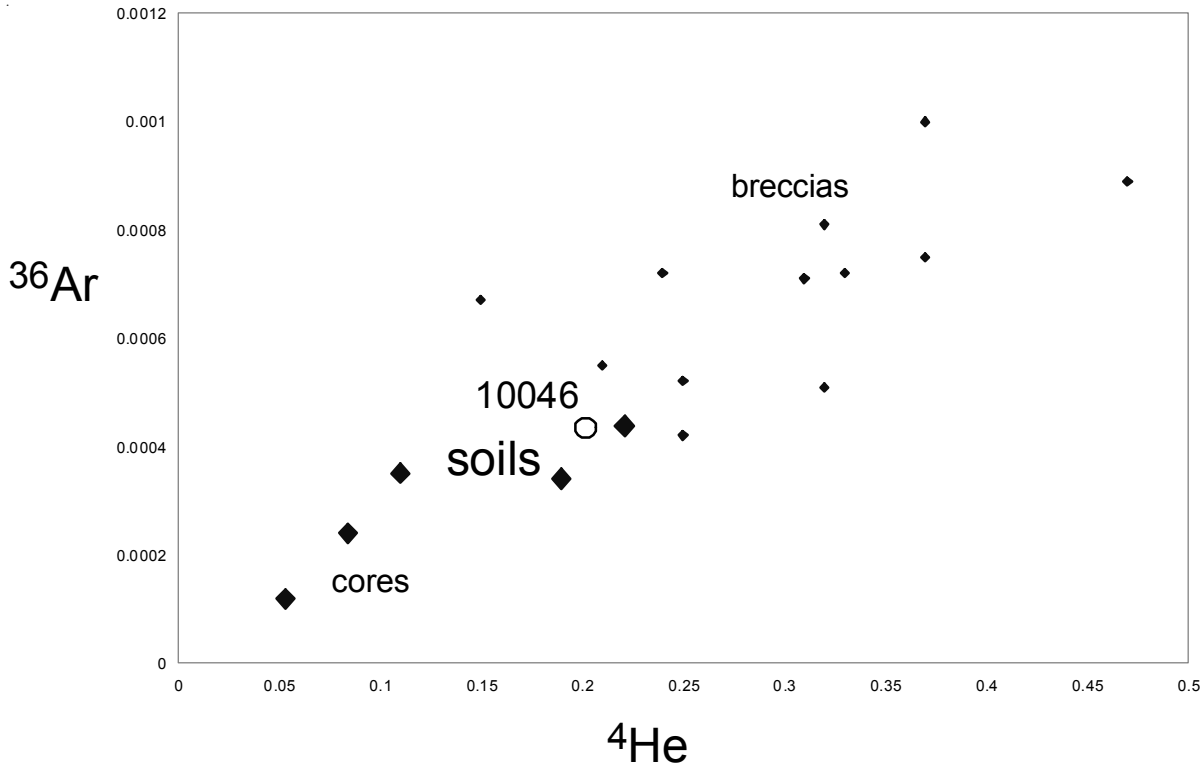


Figure 8: Implanted solar wind rare gas for 10046 compared with other Apollo 11 breccias, soils and cores (data from Funkhouser et al. 1970 and Hintenberger et al. 1976).